

ICT TOOL - TO CALCULATE MORPHOLOGICAL CHARACTERISTICS OF WATERSHED

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ABSTRACT

Morphometric analysis of any watershed provides an account about the topography of the area, geological condition and runoff potential. Linear, relief and aerial morphometric parameters are evaluated for development planning of watershed. However, there are many formulae and calculations to determine morphometric characteristics. This paper discusses how ICT tool – a programming language is efficient for calculating morphological characteristics such as stream order (u), stream length (Lu), mean stream length (Lu) and bifurcation ratio (Rb), Relief (H), Ruggedness number (HD), Drainage density (Dd), stream frequency (Fs), Form factor (Rf), circulatory ratio (Rc) and Constant Channel Maintenance (C). It has been developed by using C language compiler V 3.00 Turbo C++ copyright © 1990, 1992 by Borland International. The design calculator contains the main page where, the morphological characteristics are given. By entering the values of each parameter, all the characteristics are determined within few minutes. The results obtained were verified with the manual calculations and it was found that the results were accurate. Thus, this calculator programme is very efficient for calculating the morphological characteristics.

KEYWORDS: ICT, Morphometry, Stream, Watershed, Turbo C++

Received: Oct 08, 2016; **Accepted:** Oct 27, 2016; **Published:** Nov 11, 2016; **Paper Id.:** IJMCARDEC20168

INTRODUCTION

Morphometry is defined as the measurement of external shape and dimensions of landforms. Morphometric analysis of a watershed is an important aspect in watershed management. Detailed morphometric analysis of a watershed is helpful in understanding the influence of fluvial morphometry. Morphometric analysis of any watershed provides an account about the topography of the area, geological condition and runoff potential. Morphometric analysis is the measurement of 3 dimensional geometry of landforms and has traditionally been applied to watershed, drainages, hill slopes, and other group of terrain features (Barber, 2005). The morphometric characteristics of a watershed represent its attributes and can be helpful in synthesizing its hydrological behaviour. Morphometric parameters affect catchment stream flow pattern through their influence on concentration time.

Linear, relief and aerial morphometric parameters are evaluated for development planning of watershed. Linear parameter analyzed includes stream order (u), stream length (Lu), mean stream length (Lu) and bifurcation ratio (Rb). Relief parameter analyzed includes Basin Relief (H) and Ruggedness number (HD). Relief aspect of watersheds plays an important role for computing, surface and subsurface water flow, permeability, landform development, Drainage density (Dd), stream frequency (Fs), Form factor (Rf), circulatory ratio (Rc) and Constant

Channel Maintenance (C) which helps for drainage development. The drainage pattern differs a lot in linear, relief and areal morphometric parameters due to difference in geological structure, land form configuration, slope, vegetation and rainfall distribution

Attempt has been made to simplify the calculations using C language with the project entitled, ICT tool – To calculate the morphological characteristics of the watershed using C language, with the focus on the following objective:- To simplify the calculations to determine the morphological characteristics of watershed using C language.

MATERIALS AND METHODS

This includes the methodology used to calculate, morphological characteristics of watershed. It includes different formulae and theoretical considerations those are used for calculation.

Configuration of the System

- Windows 7 Ultimate
- Copyright @ 2009 Microsoft Corporation.
- Processor: Intel (R) Core (TM) i3-3110M CPU @ 2.40 GHz
- Installed memory (RAM): 4.00 GB

About the Platform

Turbo C++, Version 3.0, Copyright (c) 1990, 1992 by Borland International, Inc.

Morphological Characteristics of the Watershed

Morphological characterization is the systematic description of watershed geometry. Geometry of drainage basin and its stream channel system required the following measurements:

- Linear aspect of drainage network
- Areal aspect of drainage basin
- Relief aspect of channel network and contributing ground slopes

Linear Aspects of Drainage Networks

- **Stream Order**

The stream order represents the degree of stream branching with watershed.

- **Stream Number**

The count of stream channel in its order is known as stream number.

- **Bifurcation ratio (R_b)**

Bifurcation ratio is defined as the ratio of number stream segments (N_u) of a given order u to the number of stream segments of next higher order.

$$R_b = \frac{N_u}{N_{u+1}}$$

Where,

R_b = bifurcation ratio

N_u = number of streams of order u

N_{u+1} = number of streams of order u+1

- **Mean Stream Length ($\bar{L}_u$)**

Stream length is defined as the summation of the total length of all streams to the number of stream.

$$\bar{L}_u = \frac{\sum_{i=1}^N L_u}{N_u}$$

Where,

$\bar{L}_u$ = mean length of channel of order u

N_u = total number of stream segments of order u

- **Stream Length Ratio (R_L)**

It is defined as the ratio of mean length of stream segment (L_u) of order 'u' to the mean length of stream segment of next lower order.

$$R_L = \frac{\bar{L}_u}{\bar{L}_{u-1}}$$

Where,

$\bar{L}_u$ = average length of stream of order u

$\bar{L}_{u-1}$ = average length of stream of next lower order

Areal Aspects of Drainage Networks

- **Form Factor (R_f)**

Form factor is defined as the basin area to the square of the basin length.

$$R_f = \frac{A_u}{L_b^2} \text{ Where,}$$

A_u = basin area

L_b = basin length

- **Circulatory Ratio (R_c)**

Circulatory ratio is the ratio of basin area to the area of circle having equal perimeter as the perimeter of drainage basin.

$$R_c = \frac{A_u}{A_c} \text{ Where,}$$

A_u = basin area

A_c = area of circle

- **Elongation Ratio (R_l)**

It is defined as the ratio of diameter of a circle which has same area as the basin to the maximum basin length.

$$R_l = \frac{D_c}{L_{bm}}$$

Where,

D_c = diameter of circle

L_{bm} = maximum basin length

- **Drainage Density (D_d)**

It is defined as the ratio of total length of all stream segments within the watershed to the total area of the watershed.

$$D_d = \frac{L_u}{A} \text{ Where,}$$

L_u = length of stream segment

A = watershed area

- **Constant of Channel Maintenance (C)**

The constant of channel maintenance is the inverse of drainage density.

$$C = \frac{1}{D_d}$$

Where,

D_d = drainage density

- **Drainage Texture (T)**

Drainage texture is the ratio of number of the streams in watershed to the perimeter of the watershed.

$$T = \frac{N_u}{P}$$

Where,

N_u = Total number of streams of all order

P = Basin perimeter

$$L_g = \frac{1}{2D_d}$$

Where,

D_d = drainage density

Boundary map of watershed

Drainage map of watershed

Source code for calculation of morphological characteristics of the watershed using C language

```
#include <stdio.h>

#include<math.h>

#include<conio.h>

void main()

{

    float a,b1,b2,b3,b4,b5,b6,b7,c1,c2,c3,c4,c5,c6,d1,d2,d3,d4,d5,d6,d7,e1,e2,e3,e4,e5,e6,e7,f1,f2,f3,f4,f5,f6,g,h,i,j,k,l
,m,n,o,p,q,r,s,t,u,v,w,x,y;

    int kk, choice = 0;

    clrscr();

    // while statement start

    while (choice!=17)

    {

        clrscr();

        // setcolor(10); //

        printf("\n\t\t***Department of Soil and Water Conservation    Engineering***\n\n\t\t");

        printf("\t\tMorphological Characteristics of Watershed \n\n");

        printf("\t\tA. Linear aspects of drainage networks: \n");

        printf("\t\t\t1. Stream Order \n");

        printf("\t\t\t2. Stream Number \n");

        printf("\t\t\t3. Bifercation Ratio\n");

        printf("\t\t\t4. Mean Stream Length \n");

        printf("\t\t\t5. Stream Length Ratio \n");

        printf("\t\tB. Areal aspects of drainage networks: \n");
```

```

printf("\t\t 6. Form Factor \n");
printf("\t\t 7. Circulatory Ratio \n");
printf("\t\t 8. Elongation Ratio\n");
printf("\t\t 9. Drainage Density \n");
printf("\t\t 10. Constant of Channel Maintanence \n");
printf("\t\t 11. Drainage Texture \n");
printf("\t C. Relief aspects of drainage networks: \n");
printf("\t\t 12. Relief\n");
printf("\t\t 13. Relief Ratio \n");
printf("\t\t 14. Relative Relief\n");
printf("\t\t 15. Ruggedness Number \n");
printf("\t\t 16. Length of Overland Flow \n");
printf("\t\t 17.EXIT \n");
printf("\n\t ENTER YOUR CHOICE <1 -17>");
scanf("%d",&choice);
switch (choice)
{
Case 1: /*Stream order*/
{
clrscr();
printf("\n\t\t***Department of Soil and Water Conservation Engineering***\n\n\t\t");
printf("\t Morphological Characteristics of Watershed \n\n");
printf("\t A. Linear aspects of drainage networks: \n");
printf("\n\n\t Enter the order of stream \t=\t");
scanf("%f",&a);
getch();
break;
}
Case 2: /*Stream Number*/

```

```

{
    clrscr();

    printf("\n\t\t***Department of Soil and Water Conservation    Engineering***\n\t\t");
    printf("\t Morphological Characteristics of Watershed \n\n");
    printf("\t A. Linear aspects of drainage networks: \n");
    printf("\n\n\t Enter the number of streams of first order \t=\t");
    scanf("%f",&b1);

    printf("\n\n\t Enter the number of streams of second order \t=\t");
    scanf("%f",&b2);

    printf("\n\n\t Enter the number of streams of third order \t=\t");
    scanf("%f",&b3);

    printf("\n\n\t Enter the number of streams of fourth order \t=\t");
    scanf("%f",&b4);

    getch();

    break;
}

```

Case 3: /*Bifurcation Ratio*/

```

{
    clrscr();

    printf("\n\t\t***Department of Soil and Water Conservation    Engineering***\n\t\t");
    printf("\t Morphological Characteristics of Watershed \n\n");
    printf("\t A. Linear aspects of drainage networks: \n");

    c1=b1/b2;

    printf("\n\n Bifurcation Ratio 1/2= %5.2f\n",c1);

    c2=b2/b3;

    printf("\n\n Bifurcation Ratio 2/3= %5.2f\n",c2);

    c3=b3/b4;

    printf("\n\n Bifurcation Ratio 3/4= %5.2f\n",c3);

    c4=b4/b5;

```



```

printf("\n\n Bifurcation Ratio 4/5= %5.2f\n",c4);

c5=b5/b6;

printf("\n\n Bifurcation Ratio 5/6= %5.2f\n",c5);

c6=b6/b7;

printf("\n\n Bifurcation Ratio 6/7= %5.2f\n",c6);

getch();

break;

}

```

Case 4: /*Mean Stream Length*/

```

{

clrscr();

printf("\n\t\t***Department of Soil and Water Conservation Engineering***\n\t\t");

printf("\t Morphological Characteristics of Watershed \n\n");

printf("\t A. Linear aspects of drainage networks: \n");

printf("\n\n\t Enter the total length of stream of first order (m) \t=\t");

scanf("%f",&d1);

e1=d1/b1;

printf("\n\n Mean Stream Length of first order stream (m)= %5.2f\n",e1);

printf("\n\n\t Enter the total length of stream of second order (m) \t=\t");

scanf("%f",&d2);

e2=d2/b2;

printf("\n\n Mean Stream Length of second order stream (m)= %5.2f\n",e2);

printf("\n\n\t Enter the total length of stream of third order (m) \t=\t");

scanf("%f",&d3);

e3=d3/b3;

printf("\n\n Mean Stream Length of third order stream (m)= %5.2f\n",e3);

printf("\n\n\t Enter the total length of stream of fourth order (m) \t=\t");

scanf("%f",&d4);

e4=d4/b4;

```

```

printf("\n\n Mean Stream Length of fourth order stream (m)= %5.2f\n",e4);

getch();

break;

}

}

}

```

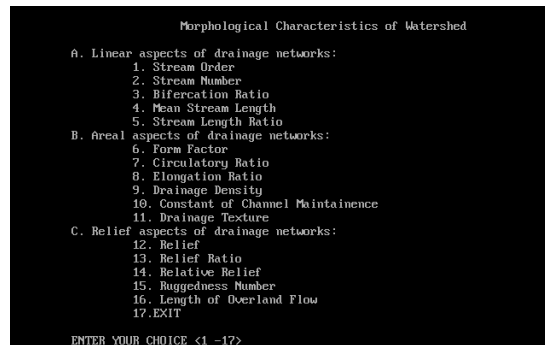
RESULTS

The results obtained by calculation of the morphological characteristics of the watershed using C++. The programme is prepared in the C language, Version 3.0 Turbo C++.

Steps to be Followed

- Enter the option from 1 to 17 serially.
- Give the input values.
- After pressing enter key, output will be displayed.
- Again press the enter key to switch over to the main page.
- Follow the same procedure to design the different parameters.

Output Screens of the Calculator to Determine the Morphological Characteristics



```

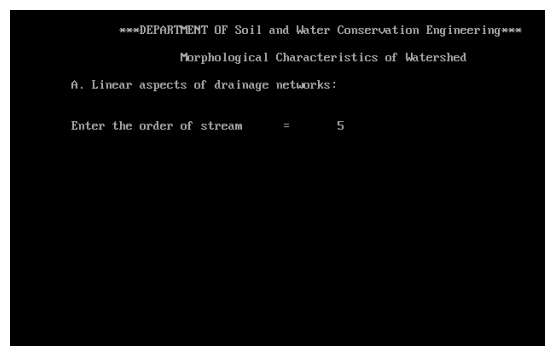
Morphological Characteristics of Watershed

A. Linear aspects of drainage networks:
1. Stream Order
2. Stream Number
3. Bifercation Ratio
4. Mean Stream Length
5. Stream Length Ratio
B. Areal aspects of drainage networks:
6. Form Factor
7. Circulatory Ratio
8. Elongation Ratio
9. Drainage Density
10. Constant of Channel Maintanence
11. Drainage Texture
C. Relief aspects of drainage networks:
12. Relief
13. Relief Ratio
14. Relative Relief
15. Ruggedness Number
16. Length of Overland Flow
17.EXIT

ENTER YOUR CHOICE <1 -17>

```

Figure 3: Output of Main Page



```

***DEPARTMENT OF Soil and Water Conservation Engineering***

Morphological Characteristics of Watershed

A. Linear aspects of drainage networks:

Enter the order of stream      =      5

```

Figure 4: Output to Enter Order of Streams

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

A. Linear aspects of drainage networks:

Enter the number of streams of first order   =      296

Enter the number of streams of second order  =       79

Enter the number of streams of third order   =       18

Enter the number of streams of fourth order  =        4

Enter the number of streams of fifth order   =        1

Enter the number of streams of sixth order   =        0

Enter the number of streams of seventh order =        0

```

Figure 5: Output to Enter the Number of Streams of Each Order

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

A. Linear aspects of drainage networks:

Bifurcation Ratio 1/2=  3.75

Bifurcation Ratio 2/3=  4.39

Bifurcation Ratio 3/4=  4.50

Bifurcation Ratio 4/5=  4.00

Bifurcation Ratio 5/6=  +INF

Bifurcation Ratio 6/7=  -NAN

```

Figure 6: Output to Determine the Bifurcation Ratio

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

A. Linear aspects of drainage networks:

Enter the total length of stream of first order (m)   =      256.4

Mean Stream Length of first order stream (m)=  0.87

Enter the total length of stream of second order (m)  =      63.04

Mean Stream Length of second order stream (m)=  0.81

Enter the total length of stream of third order (m)   =      22.41

Mean Stream Length of third order stream (m)=  1.25

Enter the total length of stream of fourth order (m)  =      _

```

Figure 7: Output to Determine the Mean Stream Length

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

A. Linear aspects of drainage networks:

Stream Length Ratio 1/2=  0.25

Stream Length Ratio 2/3=  0.35

Stream Length Ratio 3/4=  0.26

Stream Length Ratio 4/5=  4.19

Stream Length Ratio 5/6=  0.00

Stream Length Ratio 6/7=  -NAN

```

Figure8: Output to Determine the Stream Length Ratio

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

B. Areal aspects of drainage networks:

Enter the area of basin      =      132.62124

Enter the length of basin   =      22.82

Form Factor= 0.25

```

Figure 9: Output to Determine the form Factor

```

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Morphological Characteristics of Watershed

B. Areal aspects of drainage networks:

Enter the perimeter of basin =      62.51981

Circulatory Ratio= 0.43

```

Figure 10: Output to Determine Circulatory Ratio

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

B. Areal aspects of drainage networks:

Enter the maximum basin length =      22.82

Elongation Ratio= 0.57

```

Figure 11: Output to Determine Elongation Ratio

```

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Morphological Characteristics of Watershed

B. Areal aspects of drainage networks:

Drainage Density= 2.01

```

Figure 12: Output to Determine Drainage Density

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

B. Areal aspects of drainage networks:

Drainage Texture= 6.37

```

Figure 13: Output to Determine Drainage Texture

```

***DEPARTMENT OF Soil and Water Conservation Engineering***
Morphological Characteristics of Watershed

B. Areal aspects of drainage networks:

Constant of Channel Maintenance= 0.36

```

Figure 14: Output to Determine Constant of Channel Maintenance

CONCLUSIONS

- The calculations were done very accurately using C language.
- It is user friendly.
- It is time efficient.
- This is useful for determining morphological characteristics.

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